Horizontal Sight Distance at Intersections

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When designing or redesigning an intersection, or when adding an access to an existing roadway, it is necessary to determine if adequate sight distance exists for a driver negotiating the intersection. As shown in Figure 1, horizontal sight distance (d) is the leg of the sight triangle that is along the major roadway. The sight triangle is the right triangle designated by the stopped driver's eye, the middle of the intersection, and the approaching vehicle. An adequate sight distance is achieved when no part of the sight triangle is obstructed from the view of the stopped driver.

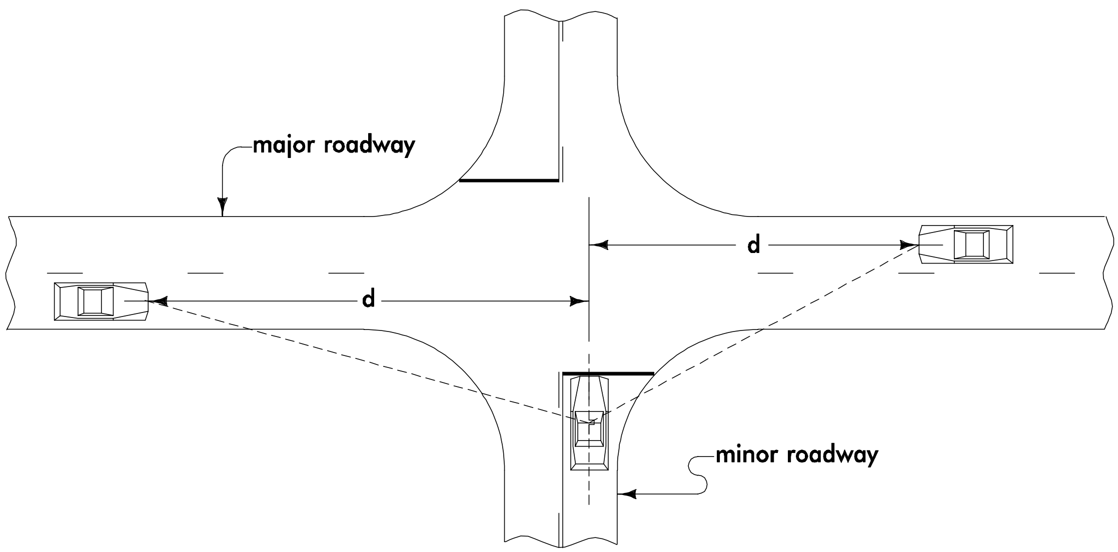


Figure 1: Horizontal sight distance.

Sight distance along the major road in excess of the minimum is desirable wherever feasible. Anything less than the minimum sight distance may restrict the safe operation of the intersection at the intended design speed. At intersections where conditions exist other than those presented herein, the designer should refer to AASHTO criteria to determine minimum horizontal sight distance requirements.

Sight distance for at grade intersections is based on a stop condition on the minor road. The sight triangle is based on the assumed location of the stopped driver's eye (normally 18 feet or 5.4 meters behind the near edge of the traveled roadway), the time required for the stopped vehicle to enter the road (left turn movement) or to clear through traffic lanes (straight-across movement), and the speed of the approaching vehicle. If site conditions (for example an immovable object such as a building) interfere with the sight triangle, the designer has the option of reducing the assumed location of the driver's eye to 14.4 feet (4.4 meters) behind the near edge of the traveled roadway; however, the designer should always start with 18 feet (5.4 meters).

For design purposes, the passenger design vehicle (or P-vehicle) is used to determine the minimum sight distance. The straight-across movement is used to determine sight distance at four-way intersections, while the left turn movement is used at "T" or ramp intersections.

Calculating Horizontal Sight Distance

The equation below takes all of the above considerations into account to determine minimum sight distances for various roadways:

$d = 1.47 \times V \times t_g$ English units $\qquad$ $d = 0.278 \times V \times t_g$ metric units

where:

- d = Minimum sight distance along the major highway from the intersection, in feet (meters):
- V = Design speed on the major highway, in mph (km/h):
- t_g = Time gap for vehicle to enter the highway (left-turn movement) or clear the through traffic lanes (straight-across movement).

Table 1 provides time gaps for left-turn and straight-across movements for various design vehicles. Time gaps are for a stopped vehicle at an intersection with a two-lane highway with no medians and grades of 3% or less. Adjustments for multi-lane highways are required as noted in the table.

Table 1: Time gaps for left-turn and straight-across movements

design vehicle	t_g left-turn movement(a) (seconds)	t_g straight-across movement(b) (seconds)
Passenger car	7.5	6.5
Single-unit truck	9.5	8.5
Combination truck	11.5	10.5

(a) For left-turns onto two-way highways with more than two lanes, add 0.5 seconds for passenger cars or 0.7 seconds for trucks for each additional lane to be crossed.

(b) For crossing a highway with more than two lanes, add 0.5 seconds for passenger cars or 0.7 seconds for trucks for each additional lane to be crossed and for narrow medians which cannot store the design vehicle.

Table 2 on the next page provides sight distance values for left-turn and straight-across movements for passenger cars. Time gaps are for a stopped vehicle at an intersection with a two-lane highway with no medians and grades of 3% or less. For other design situations the time gap should be adjusted as noted in Table 1 and sight distance recalculated.

Adjustments for Superelevation and Skew

Normally, the grade across an intersection is so small that it need not be considered, but when there is superelevation at an intersection, the acceleration time of the crossing vehicle will be affected. An adjustment factor from Table 3 on the next page based on the superelevation of the thru roadway should be applied to the values in Table 2. On Ramp and T intersections, the grade of the thru roadway will also affect the acceleration time of the left turning vehicle. Thus, an adjustment factor from Table 3 based on the grade of the thru roadway should be applied in these cases as well.

When two roads intersect at other than 90 degrees, an adjustment factor should be used for the skew angle, as shown below in Table 4 on the next page.

Table 2: Intersection Sight Distance.

English units

design speed (mph)	intersection sight distance left-turn movements (ft.)	intersection sight distance straight-across movements (ft.)
25	280	240
30	335	290
35	390	335
40	445	385
45	500	430
50	555	480
55	610	530
60	665	575
65	720	625
70	775	670
75	830	720
80	885	765

metric units

design speed (km/h)	intersection sight distance left-turn movements (m)	intersection sight distance straight-across movements (m)
20	45	40
30	65	55
40	85	75
50	105	95
60	130	110
70	150	130
80	170	145
90	190	165
100	210	185
110	230	200
120	255	220
130	275	235

Table 3: Adjustment factor for grade.

Grade*	-4% or greater	-2%	0%	+2%	+4%
Factor	0.7	0.9	1.0	1.1	1.3
Factors may be interpolated directly					

*Superelevation or grade of through roadway

Table 4: Adjustment factor for skew angle.

Angle	90	80	70	60	45
Factor	1.00	1.01	1.03	1.06	1.17
Factors may be interpolated directly					

On ramp and T-intersections, the skew angle has little effect on sight distance for left turn movements; therefore no adjustment is required.

Example

Determine the minimum sight distance for the four-way intersection of a two-lane undivided major highway with a minor road under stop control. The design speed of the major roadway is 55 mph with a cross slope of +3.5% and a skew angle of 75 degrees.

1. Since this is a four-way intersection, there will be left-turn and straight-across movements. Using Table 2 and a design speed of 55 mph the sight distance (d) is 610 feet.
2. Interpolate the adjustment factor from Table 4 for a 75 degree skew:

   $$1.01 + 0.5 \text{ x } (1.03\text{-}1.01) = 1.02$$

3. Interpolate the correction factor from Table 2 for a +3.5% cross slope:

   $$1.1 + 0.75 \text{ x } (1.3\text{-}1.1) = 1.25$$

4. Substitute into the following formula:

   $$d_{corr} = (d) \text{ x } (\text{Skew Adjustment Factor}) \text{ x } (\text{Grade Adjustment Factor})$$

   $$d_{corr} = (610') \text{ x } (1.02) \text{ x } (1.25) = 777.75'$$

5. Round d_{corr} to next higher 5′ increment:

   $$d_{corr} = 780' \text{ minimum sight distance}$$

The same procedure is used for metric units.

Procedures for Applying Horizontal Sight Distance

At the intersection of two roads or a road and a ramp, the minimum sight distance along the thru highway is taken from Table 2 or calculated using the formula from the same page, adjusted by the factors in Tables 3 and 4, and applied as shown in Figures 2 through 8 to determine the minimum sight triangle required for the intersection to function safely. Appropriate design modifications should be made, when required, to provide a sight triangle free of obstructions extending above the driver's line of sight. Typical obstructions might be trees, buildings, guardrails, bridge rails or poor horizontal and vertical alignment. When determining the driver's line of sight, assume both the height of the driver's eye and the top of an approaching vehicle to be 3.50 feet (1080 millimeters). Although the actual top of a vehicle is taken to be 4.35 feet (1330 millimeters), AASHTO recommends using an object height 10 inches (250 millimeters) less than that, as this is portion of the vehicle that needs to be visible for another driver to recognize the object as a vehicle.

Unique Situations

Figures 2 through 8 are designed to illustrate how sight distance is determined and used in unique situations that the designer might face. For example, Figure 2 considers the case where the major roadway is curved; thus the sight distance must be applied along a curved path. Figure 3 illustrates typical sight distance requirements at a T intersection.

Figure 4 illustrates a situation where the minor road intersects a four-lane roadway and the median is wide enough to accommodate a car. On such roadways (those with medians of 40 feet or 12 meters and wider), the sight distance can be treated as two stop conditions. The first is the normal stop, and the second is within the protection of the median.

Figure 5 indicates the use of sight distance in determining whether an access to either the major or minor road should be permitted. However even if the sight distance would permit it, no public or private access to the major roadway will be allowed within 300 feet (100 meters) of the intersection, measured along the centerline of the major roadway. Similarly, no portion of an access to the sideroad will be allowed within 100 feet (30 meters) of the near edge of the major roadway's thru traffic lane, measured along the centerline of the side road. These criteria are to be used only at intersections of a secondary road with a primary road. For other types of roadway intersections, refer to IAC 761-Chapter 112(306A) governing access.

Figure 6 indicates the requirements at diamond-type interchanges and Figure 7 illustrates typical sight distance requirements for ramp intersections. At interchanges where loop or directional-type movements are provided, provision for unobstructed sight distance should be made in all quadrants providing these types of movements.

Railroad Crossings

Figure 8 represents the sight distance requirements for at-grade railroad crossings. An unobstructed line of sight should be provided within the sight triangle. The sight triangle should assume the height of the driver's eye to be 3.50 feet (1080 millimeters) and the height of the approaching train to be 4.35 feet (1330 millimeters). We use 4.35 feet (1330 millimeters) as a conservative number for the train height due to the lack of direction from AASHTO on this matter.

Sight distances of the order shown in Table 5 (on page 12) are desirable at any railroad-grade crossing not controlled by active warning devices. The attainment of those distances, however, is difficult and often impractical, except possibly in flat, open terrain.

In other than flat terrain, it may be necessary to rely on speed control signs and devices and to base sight distance on a reduced vehicle speed. Where sight obstructions are present, it may be necessary to install active traffic control devices that will bring all highway traffic to a stop before crossing the tracks and will automatically warn drivers in time to avoid an approaching train. Below are definitions of quantities used in Figure 8.

V_v = Velocity of the vehicle in mph or km/h (the design speed of the highway).

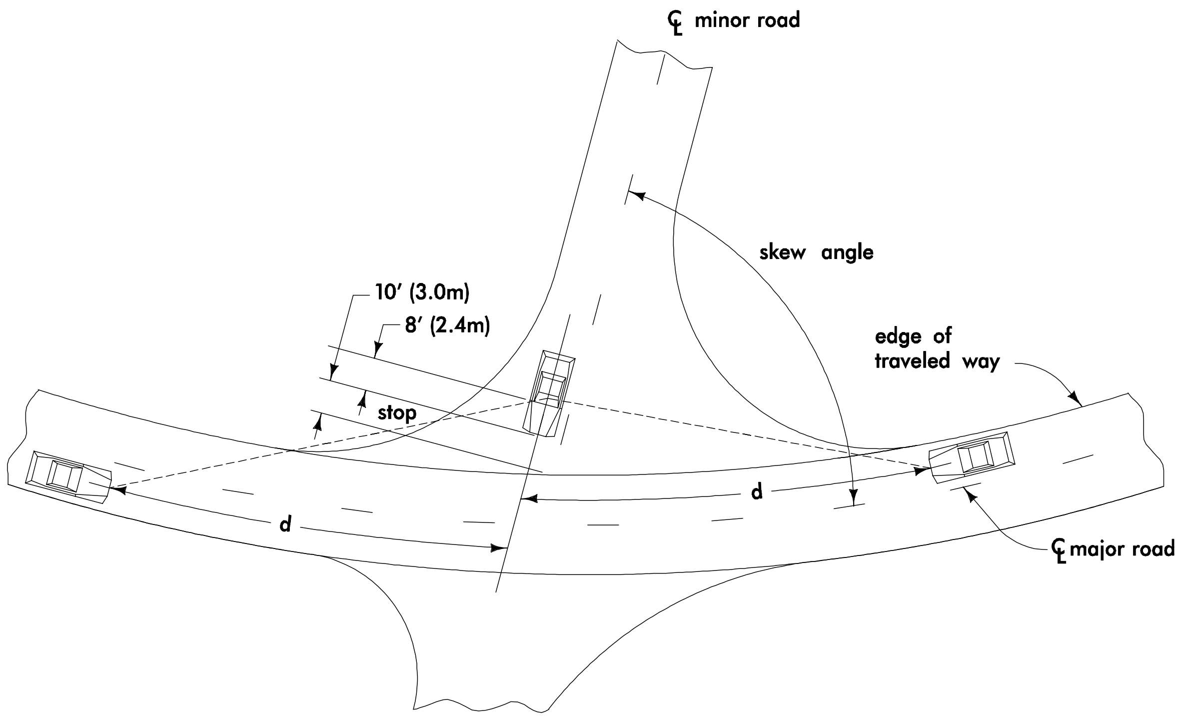
d_H = Sight distance leg along the highway (based on V_v only). This allows the driver of a vehicle proceeding at speed V_v to observe the tracks (with or without an active warning device) and to safely stop without encroaching into the crossing area.

V_T = velocity of the train in mph or km/h.

d_T = Sight distance leg along the railroad tracks (based on V_v and V_T). This and d_H are used to determine the minimum sight triangle that will permit the vehicle's driver to cross the tracks safely even though a train is observed at the distance d_T from the crossing.

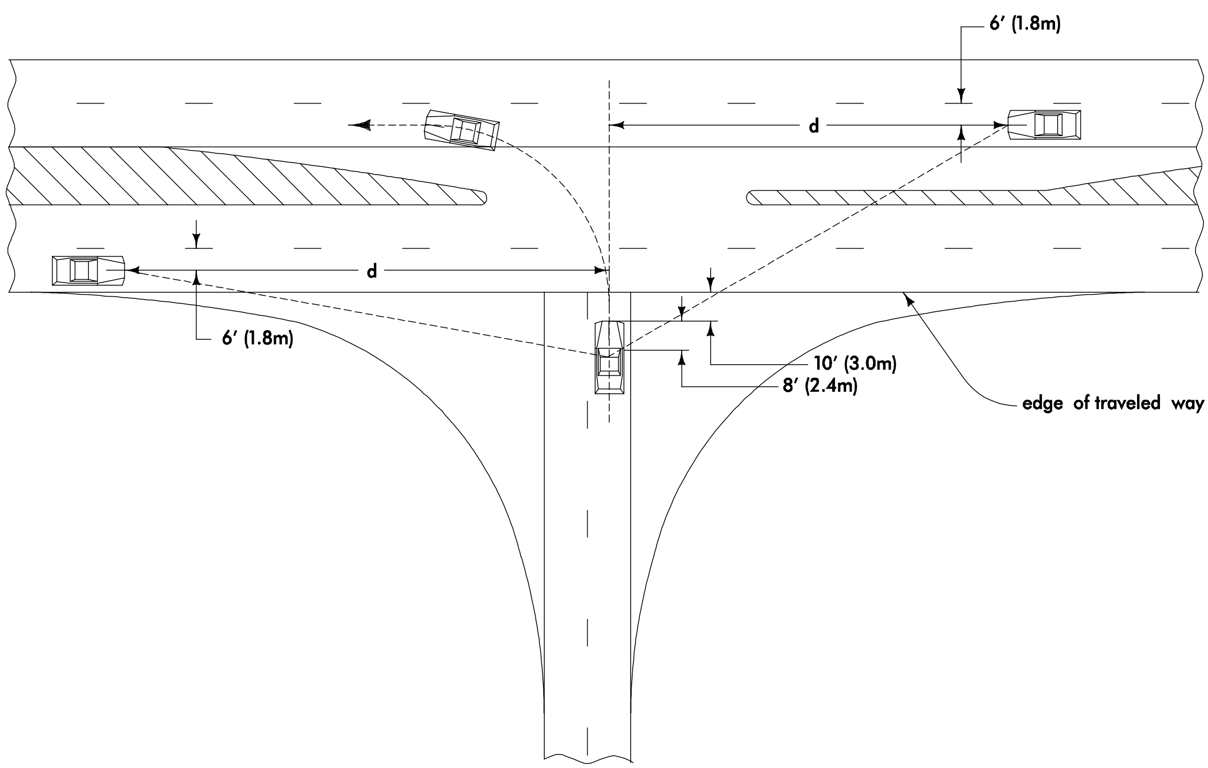
Concluding Remarks

It is desirable to have sight distances along the major road in excess of the minimum wherever feasible. Thus, it should be stressed that this is a minimum sight distance, and anything less may restrict the safe operation of the intersection at the intended design speed. At intersections where conditions exist other than those presented herein, the designer should refer to AASHTO criteria and the information presented at the first part of this section in determining minimum sight distance requirements.



CURVED MAJOR ROADWAY INTERSECTION

Figure 2: Curved major roadway



"T" INTERSECTION

Figure 3: T intersection.

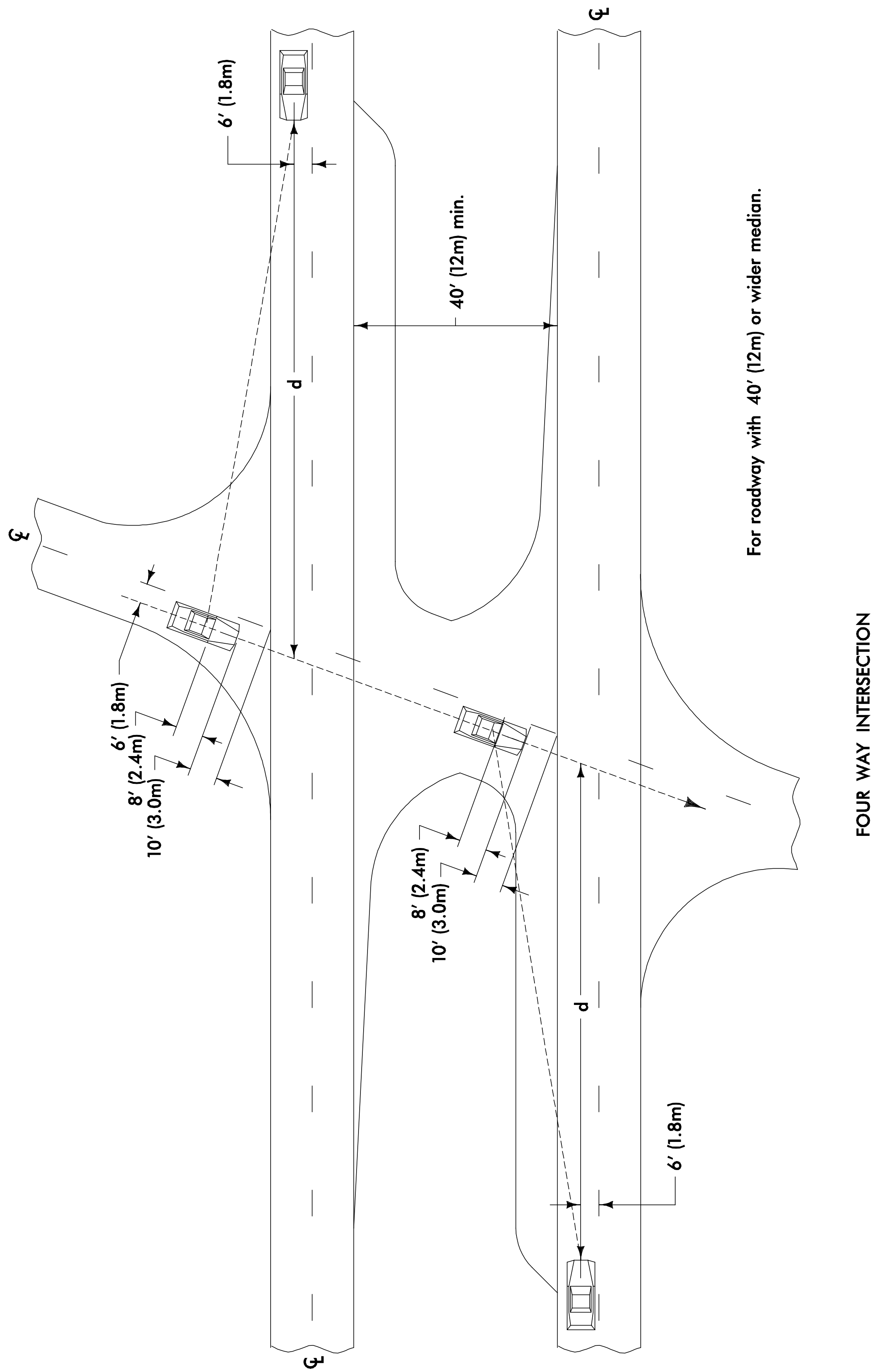


Figure 4: Four-way intersection (divided roadway).

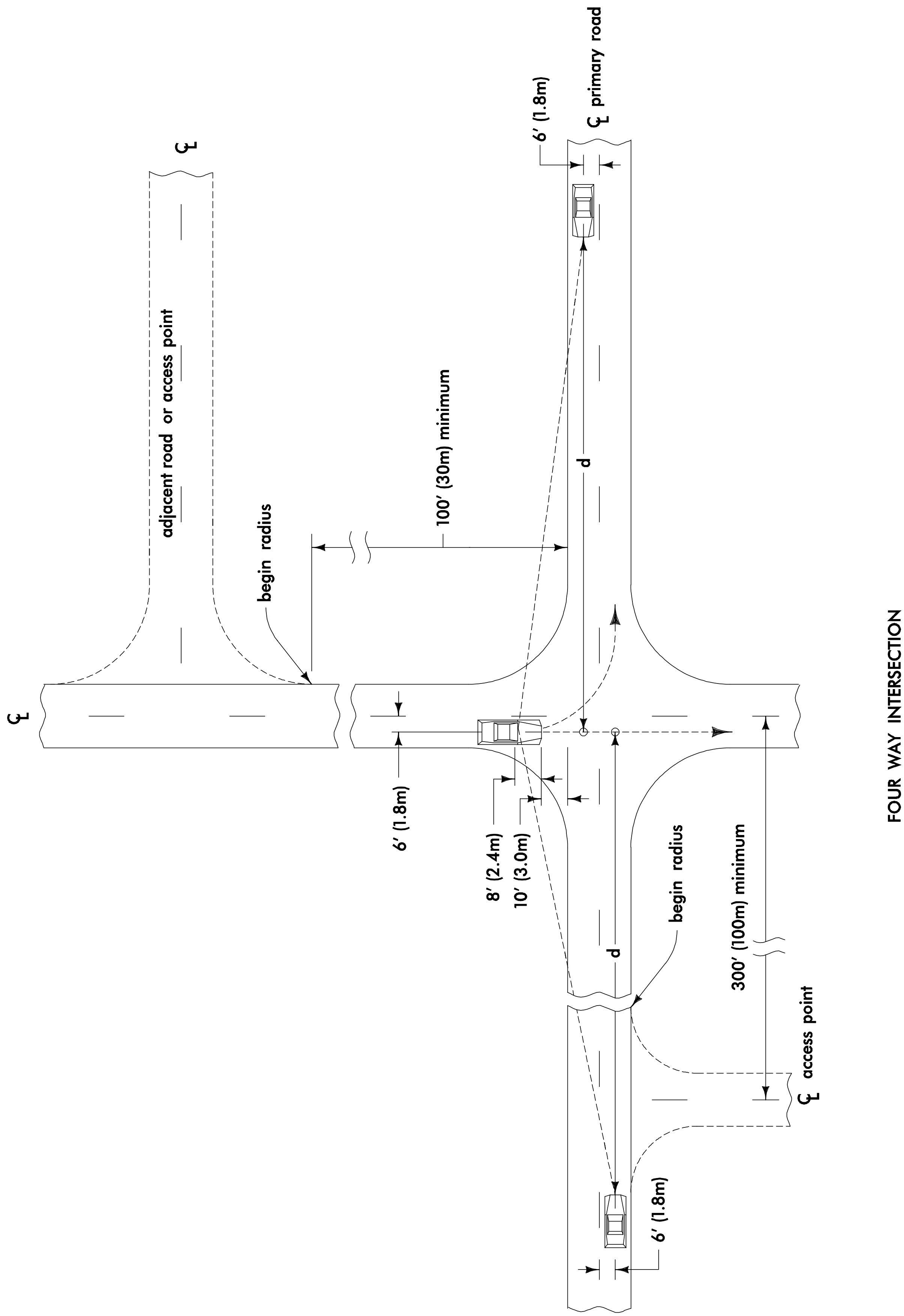


Figure 5: Four-way intersection (with secondary road).

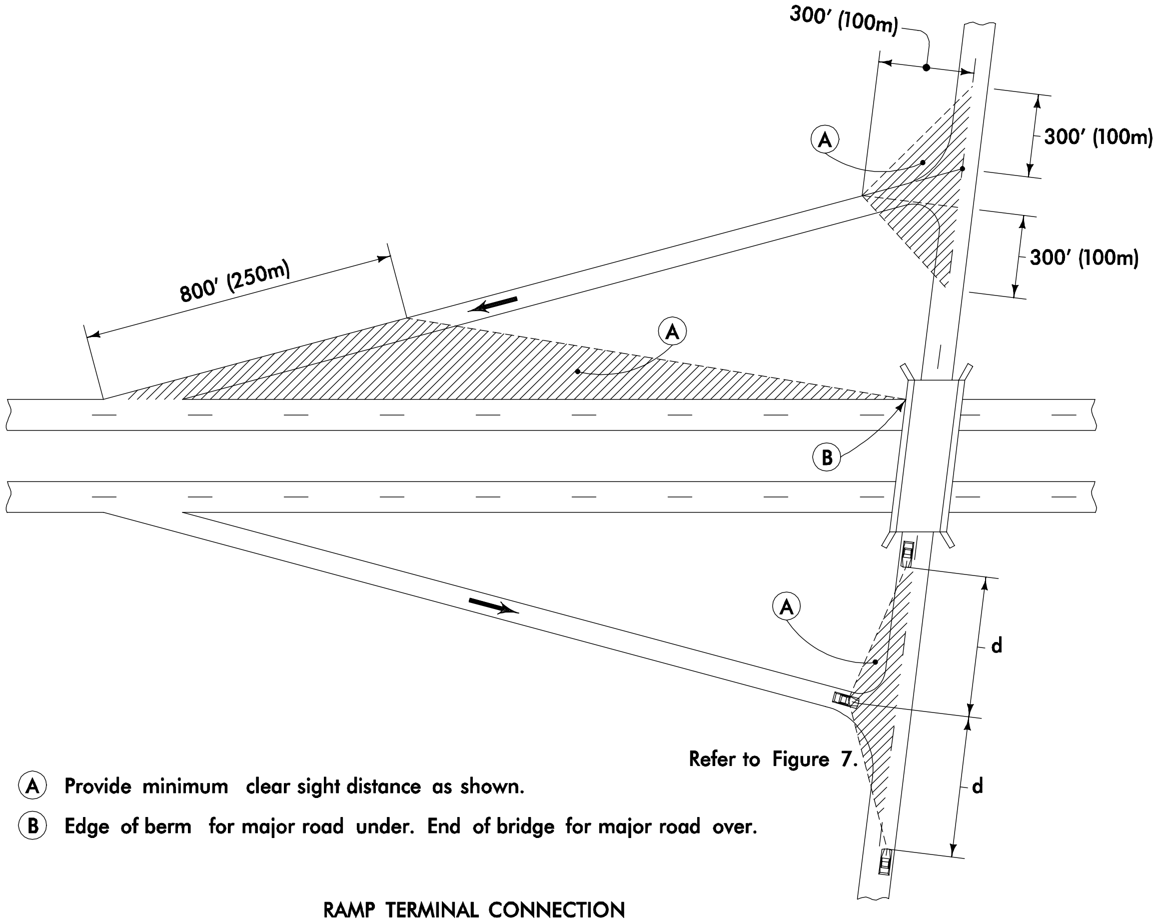


Figure 6: Ramp terminal connection.

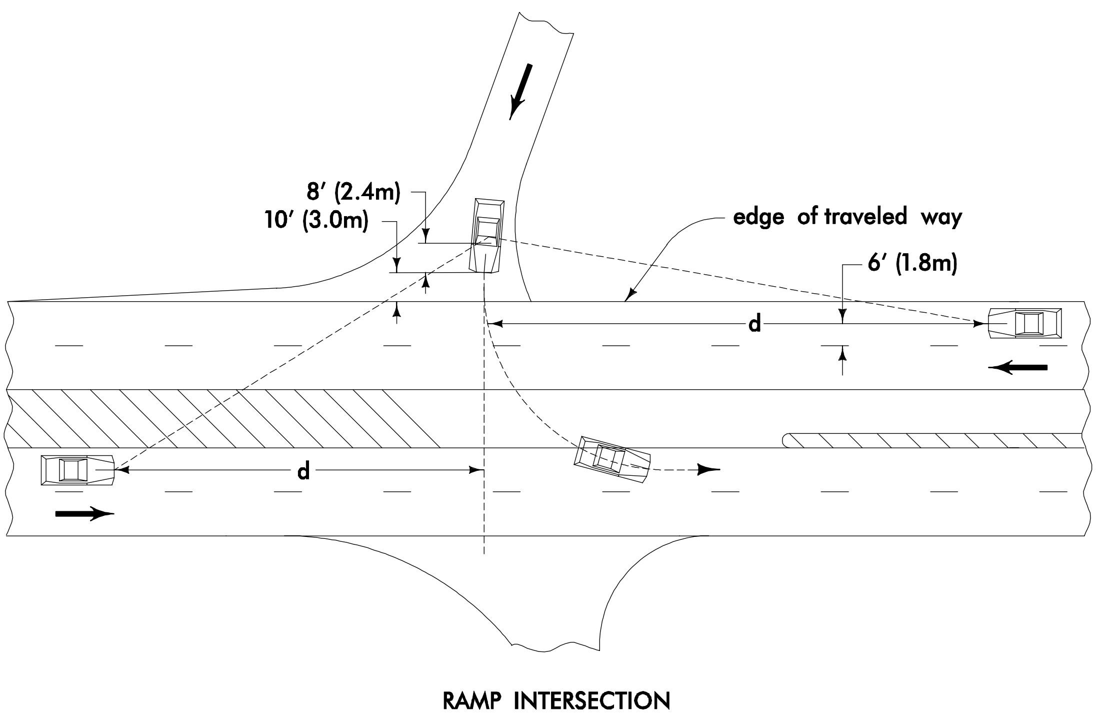


Figure 7: Ramp intersection.

Table 5: Required design sight distance for railroad-grade crossings—65-foot (20-meter) truck crossing a single set of tracks at 90 degrees). Use with Figure 8 on next page.

English units

Train Speed (mph) V_T	Vehicle Speed (mph) V_v							
	10	20	30	40	50	60	70	80
	Distance along highway for crossing (ft) d_H							
	71	137	222	326	449	591	753	933
	Distance along railroad from crossing (ft) d_T							
10	146	106	99	100	105	111	118	126
20	293	212	198	200	209	222	236	252
30	439	318	297	300	314	333	355	378
40	585	424	396	401	419	444	473	504
50	732	530	494	501	524	555	591	630
60	878	636	593	601	628	666	709	756
70	1,024	742	692	701	733	777	828	882
80	1,171	848	791	801	838	888	946	1,008
90	1,317	954	890	901	943	999	1,064	1,134

metric units

Train speed (km/h) V_T	Vehicle Speed (km/h) V_v												
	10	20	30	40	50	60	70	80	90	100	110	120	130
	Distance along highway for crossing (m) d_H												
	16	26	39	54	71	90	112	137	163	192	223	256	292
	Distance along railroad from crossing (m) d_T												
10	39	24	21	19	19	19	19	20	21	21	22	23	24
20	77	49	41	38	38	38	39	40	41	43	45	47	48
30	116	73	62	57	56	57	58	60	62	64	67	70	73
40	154	98	82	77	75	76	77	80	83	86	89	93	97
50	193	122	103	96	94	95	97	100	103	107	112	116	121
60	232	147	123	115	113	113	116	120	124	129	134	140	145
70	270	171	144	134	131	132	135	140	145	150	156	163	169
80	309	196	164	153	150	151	155	160	165	172	179	186	194
90	347	220	185	172	169	170	174	179	186	193	201	209	218
100	386	245	206	192	188	189	193	199	207	215	223	233	242
110	425	269	226	211	207	208	213	219	227	236	246	256	266
120	463	224	247	230	225	227	232	239	248	258	268	279	290
130	502	318	267	249	244	246	251	259	269	279	290	302	315
140	540	343	288	268	263	265	271	279	289	301	313	326	339

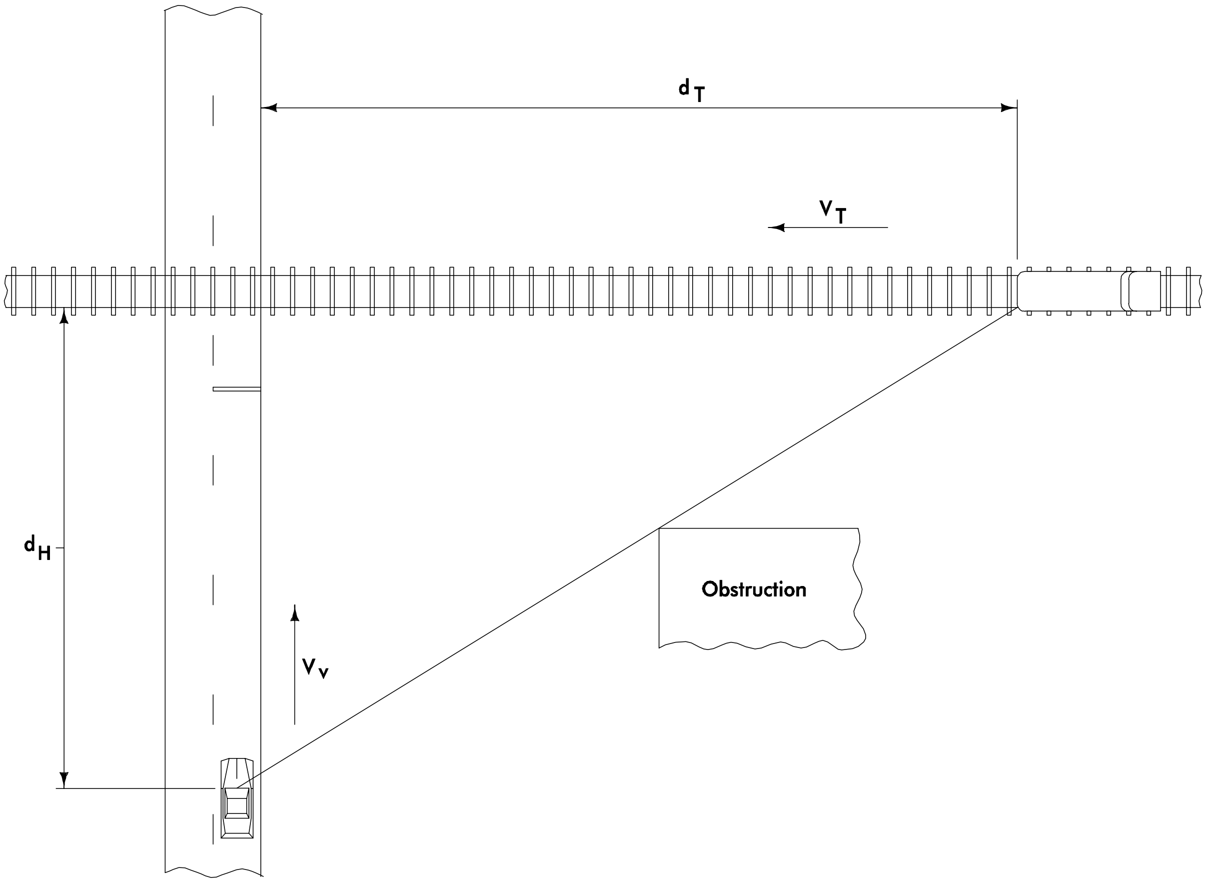


Figure 8: Railroad highway crossing.